Introduction to cell physiology

Physiology (from the Greek physis = nature; logos = study) is the science that seeks to explain the physical and chemical mechanisms that are responsible for the origin, development, and progression of life. Or Physiology is the science that is concerned with studying how the various functions of the organism occur, such as the work of the circulatory system, the respiratory system, the muscular system, the endocrine glands...etc. Each type of life, from the simplest virus to the largest tree or the complicated human being, has its own functional characteristics.

Human Physiology

The science of human physiology attempts to explain the specific characteristics and mechanisms of the human body that make it a living being. The fact that we remain alive is the result of complex control systems. Hunger makes us seek food, and fear makes us seek refuge. Sensations of cold make us look for warmth. Other forces cause us to seek fellowship and to reproduce. The fact that we are sensing, feeling, and knowledgeable beings is part of this automatic sequence of life; these special attributes allow us to exist under widely varying conditions, which otherwise would make life impossible.

Levels of Organization

In a multicellular organism levels are:

cells ⟶ tissues ⟶ organs ⟶ organ systems

tissues: group of similar cells that perform same function.

organ: group of tissues that work together to perform complex function.

organ system: group of organs that perform closely related functions.

Cells are the living units of the body

The basic living unit of the body is the cell. Each organ is an aggregate of many different cells held together by intercellular supporting structures. Each type of cell is specially adapted to perform one or a few particular functions. Although the many cells of the body often differ markedly from one another, all of them have certain basic characteristics that are alike.

For instance the entire body, contains about 100 trillion cells, the red blood cells, numbering about 25 trillion in each human being, transport oxygen from the lungs to the tissues. about 75 trillion additional cells of other types perform functions different from those of the red blood cell.

Oxygen reacts with carbohydrate, fat, and protein to release the energy required for all cells to function.

Further, the general chemical mechanisms for changing nutrients into energy are basically the same in all cells, and all cells deliver products of their chemical reactions into the surrounding fluids. Almost all cells also have the ability to reproduce additional cells of their own kind. Fortunately, when cells of a particular type are destroyed, the remaining cells of this type usually generate new cells until the supply is replenished.

The main objective of physiological studies

The main goal of physiology is to understand the meaning of life (the normal functioning of cells, organs, and systems) through

1- Know what is the function?
2- How to perform this function?
3- What are the factors affecting the function?
4- How does this function integrate with other functions?

The basic principles of physiology on which the activity of an organism depends:

- **Extracellular fluid—the "internal environment"**

About 60 percent of the adult human body is fluid, mainly a water solution of ions and other substances. Although most of this fluid is inside the cells and is called intracellular fluid, about one third is in the spaces outside the cells and is called extracellular fluid. This extracellular fluid is in constant motion throughout the body. It is transported rapidly in the circulating blood and then mixed between the blood and the tissue fluids by diffusion through the capillary walls. In the extracellular fluid are the ions and nutrients needed by the cells to maintain life. Thus, all cells live in essentially the same environment—the extracellular fluid. For this reason, the extracellular fluid is also called the internal environment of the body, or the milieu intérieur, a term introduced by the 19th-century French physiologist Claude Bernard (1813–1878). Cells are capable of living and performing their special functions as long as the proper concentrations of oxygen, glucose, different ions, amino acids, fatty substances, and other constituents are available in this internal environment.

The intracellular fluid differs significantly from the extracellular fluid; The extracellular fluid contains large amounts of sodium, chloride, and bicarbonate ions plus nutrients for the cells, such as oxygen, glucose, fatty acids, and amino acids. It also contains carbon dioxide that is being transported from the cells to the lungs to be excreted, plus other cellular waste products that are being transported to the kidneys for excretion. While the fluid inside the cell contains large amounts of potassium, magnesium and phosphate ions instead of the ions found in the extracellular fluid. Special mechanisms of ion transport across cell membranes maintain ion concentration differences between extracellular fluids and intracellular fluids.

- **Extracellular fluid transport and mixing system—the blood circulatory system**

Extracellular fluid is transported through the body in two stages. The first stage is movement of blood through the body in the blood vessels, and the second is movement of fluid between the blood capillaries and the intercellular spaces between the tissue cells. All the blood in the circulation traverses the entire circulatory circuit an average of once each minute when the body is at rest and as many as six times each minute when a person is extremely active. As blood passes through the blood capillaries, continual exchange of extracellular fluid also occurs between the plasma portion of the blood and the interstitial fluid that fills the intercellular spaces. This process is shown in Figure 2. The walls of the capillaries are permeable to most molecules in the plasma of the blood, with the exception of plasma proteins, which are too large to readily pass through the capillaries. Therefore, large amounts of fluid and its dissolved constituents diffuse back and forth between the blood and the tissue spaces, as shown by the arrows. This process of diffusion is caused by kinetic motion of the molecules in both the plasma and the interstitial fluid. That is, the fluid and dissolved molecules are continually moving and bouncing in all directions within the plasma and the fluid in the intercellular spaces, as well as through the capillary pores. Thus, the extracellular fluid everywhere in the body—both that of the plasma and that of the interstitial fluid—is continually being mixed, thereby maintaining homogeneity of the extracellular fluid throughout the body.

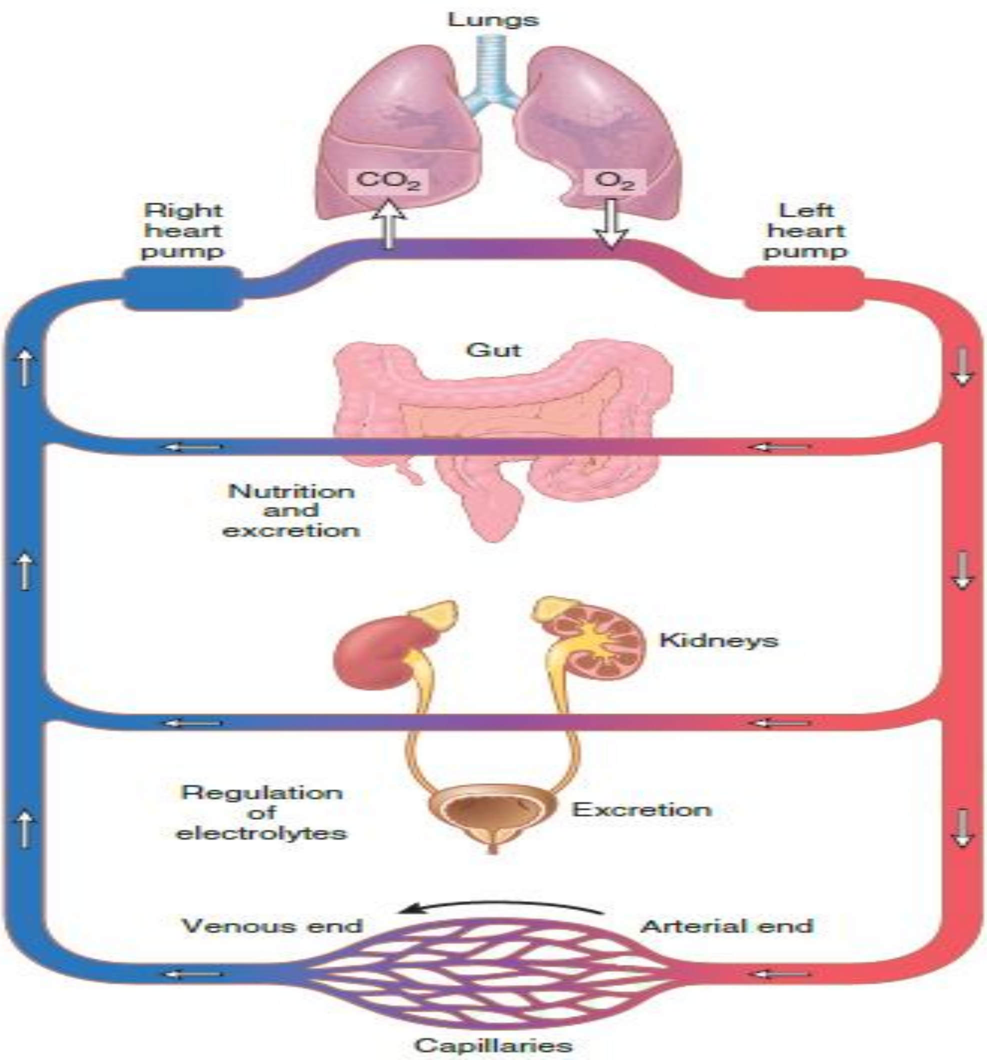

Figure 1. General organization of the circulatory system.

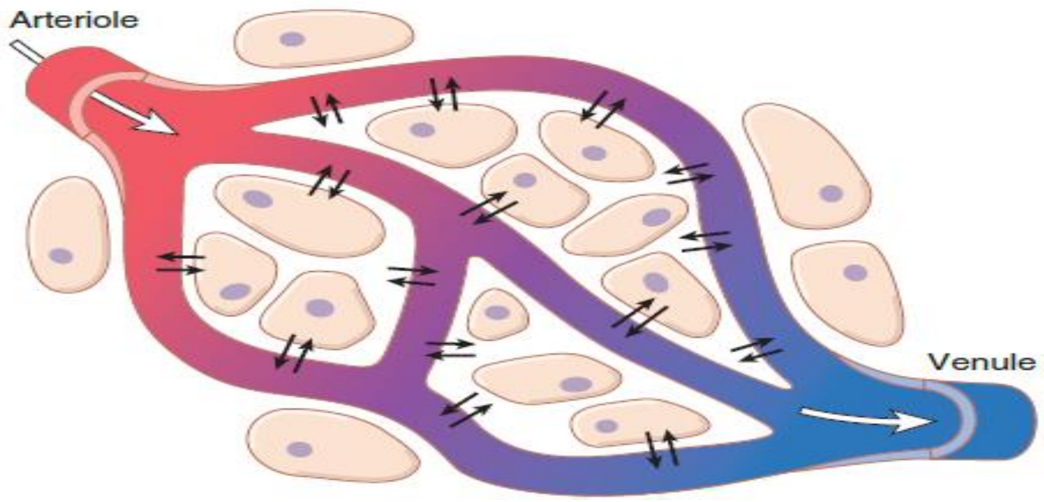

Figure 2. Diffusion of fluid and dissolved constituents through the capillary walls and through the interstitial spaces.

- **Homeostasis**

All that the cells need to survive (oxygen, glucose, mineral ions, waste removal, and so forth) is necessary for the well-being of individual cells and the well-being of the entire body. The varied processes by which the body regulates its internal environment are collectively referred to as homeostasis, and maintained of the regulatory mechanisms and balance of the body can by negative feedback loops.

Homeostasis in a general sense refers to stability and balance. It is the body's attempt to maintain a constant internal environment. Maintaining a stable internal environment requires constant monitoring and adjustments as conditions change. This adjusting of physiological systems within the body is called homeostatic regulation.

The concept of homeostasis has been of immense value in the study of physiology because it allows diverse regulatory mechanisms to be understood in terms of their "why" as well as their "how." The concept of homeostasis also provides a major foundation for medical diagnostic procedures.

Homeostatic regulation involves three parts or mechanisms:

1) the receptor.

2) the control center.

3) the effector.

The receptor receives information that something in the environment is changing. The control center or integration center receives and processes information from the receptor. And lastly, the effector responds to the commands of the control center by either opposing or enhancing the stimulus. This is an ongoing process that continually works to restore and maintain homeostasis.

For example, in regulating body temperature there are temperature receptors in the skin, which communicate information to the brain, which is the control center, and the effector is our blood vessels and sweat glands. The integrating center is often a particular region of the brain or spinal cord, and can be a group of cells in an endocrine gland. A number of different sensors may send information to a particular integrating center, which can then integrate this information and direct the responses, effectors generally muscles or glands. The integrating center may cause increases or decreases in effector action to counter the deviations from the set point and defend homeostasis. Because the internal and external environment of the body are constantly changing and adjustments must be made continuously to stay at or near the set point, homeostasis can be thought of as a synthetic equilibrium.

Negative feedback: a reaction in which the system responds in such a way as to reverse the direction of change. Since this tends to keep things constant, it allows the maintenance of homeostasis or a response mechanism that serves to maintain a state of internal constancy, or homeostasis.

For instance, when the concentration of carbon dioxide in the human body increases, the lungs are signaled to increase their activity and expel more carbon dioxide. Thermoregulation is another example of negative feedback, when body temperature rises (or falls), receptors in the skin and the hypothalamus sense a change, triggering a command from the brain, this command in turn effects the correct response. in this case the temperature of body is lowering.

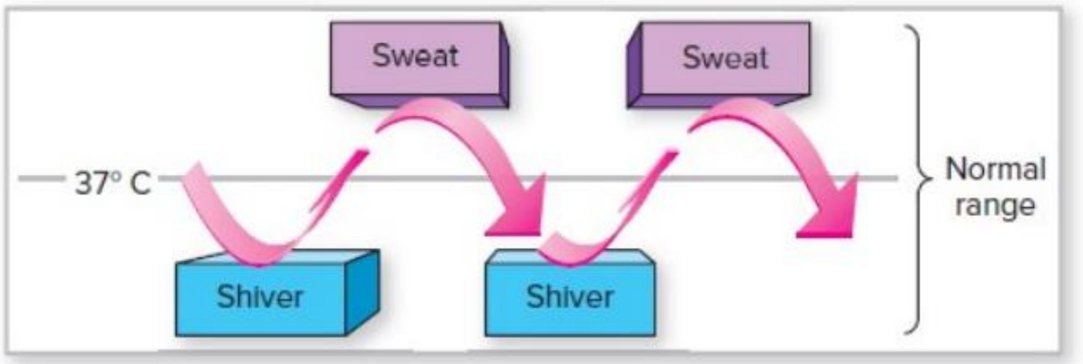

Figure 3. How body temperature is maintained within the normal range. The body temperature normally has a set point of 37° C.

Positive feedback: a response is to amplify the change in the variable. This has a destabilizing effect, so does not result in homeostasis. Positive feedback is less common in naturally occurring systems than negative feedback, but it has its applications. For example, Blood clotting and the production of the LH surge by the stimulatory effect of estrogen that triggers ovulation and contraction of the uterus during childbirth (parturition) are other types of positive feedback.

Positive Feedback it also can be harmful at times. When you have a high fever it causes a metabolic change that can push the fever higher and higher. In rare occurrences the body temperature reaches 113 degrees and the cellular proteins stop working and the metabolism stops, resulting in death.

- **Metabolism**

The living organism obtains the energy necessary for its growth, the restoration of its organs and the completion of its vital activities from food. The energy is released through complex chemical reactions through which large molecules are broken down into simple molecules or oxidized into water and carbon dioxide. This process of catabolism is called catabolism. He himself builds complex materials from simple materials called the process of anabolism, and the end result of the processes of building and demolition is called metabolism.